



NAVAL POSTGRADUATE SCHOOL

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THESIS

**INFORMATION MANAGEMENT UTILIZING VALUED
INFORMATION AT THE RIGHT TIME (VIRT) AS
APPLIED TO A JOINT TERMINAL ATTACK
CONTROLLER (JTAC) MISSION**

by

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March 2008

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CONTROLLER (JTAC) MISSION**

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ABSTRACT

This research utilizes the JTAC mission and applies the VIRT concept of smart-push information delivery. Current efforts within DoD focus on achieving a virtual world where all information becomes available through the GIG. This pull approach to information delivery does not adequately address the value of information and the absolute requirement to deliver it to the lowest levels when and where needed. The current DoD enterprise-wide mentality of IT implementation does not focus on where best to leverage IT in order to achieve an immediate increase in capability. VIRT, as demonstrated in this research, provides an excellent place to start and a great opportunity to utilize technology in an effective way without taking a decade for implementation.

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LIST OF ABBREVIATIONS

Advanced Field Artillery Tactical Data System	AFATDS
Air Force Material Command	AFMC
Area of Responsibility	AOR
Battle Damage Assessment	BDA
Blue Force Tracker	BFT
Close Air Support	CAS
Commanders Critical Information Requirement	CCIR
Condition of Interest	COI
Condition Monitor	CM
Cooperative Engagement Capability	CEC
Department of Defense	DoD
Casualty Evacuation	CASEVAC
Command and Control Personal Computer	C2PC
Common Operational Picture	COP
Cooperative Engagement Capability	CEC
Cursor on Target	CoT
Defense Information Systems Agency	DISA
Distributed Intelligent Control and Management	DICAM
Extensible Mark-up Language	XML
Fiscal Year	FY
Force 21 Base and Command Brigade and Below	FBCB2
Forward Air Controller	FAC
Global Information Grid	GIG
Global Positioning Satellite	GPS
Graphical User Interface	GUI
Headquarters	HQ
Information Technology	IT
Joint Close Air Support	JCAS
Joint Forces Command	JFCOM

Joint Tactical Air Request	JTAR
Joint Terminal Attack Controller	JTAC
Joint Vision	JV
Machine to Machine	M2M
Modular Universal Laser Equipment	MULE
Naval Postgraduate School	NPS
Naval Surface Fire Support	NSFS
Net Centric Operations	NCO
Net Centric Warfare	NCW
Observation Position	OP
Query Processor	QP
Personal Digital Assistant	PDA
Revolution in Military Affairs	RMA
Situational Awareness	SA
Standard General Markup Language	SGML
Standard Operating Procedure	SOP
Target Location Designation and Hand Off System	TLDHS
Unmanned Aerial Vehicle	UAV
User Defined Operational Picture	UDOP
Valued Information at the Right Time	VIRT
Very High Frequency	VHF
Work in Progress	WIP

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I. INTRODUCTION

A. THE JOINT MISSION

Today's warrior understands the importance in utilizing technology to gain and maintain advantage over his enemies. DoD faces the challenge of utilizing new and existing technology to ensure success in the battle-space of today and tomorrow. Net-Centric Warfare (NCW) has become a buzzword, but how does the warfighter translate this concept into an enabling capability? Specifically, how does the military transform itself into a truly network centric force spanning all services?

The Joint Forces Command (JFCOM) as one of the nine unified commands faces the unique mission of uniting and supporting the efforts of the other geographic commanders. As a result, the JFCOM ardently advocates jointness within the Department of Defense (DoD). JFCOM faces some extreme challenges. A few of these challenges derive from the cultural differences among the services and the myriad technological applications. In order for the DoD to achieve success today and in the future, these challenges must be overcome. Each service can no longer pursue missions based entirely on inherent capabilities. Any Revolution in Military Affairs (RMA) within the DoD must focus on a unity of effort amongst the services. How does the military take such a large task and translate it into real capabilities on the ground? What enabling technologies exist? What road map should DoD follow?

1. Purpose of Research

This thesis seeks to identify current efforts to enable a net centric force, e.g., the Global Information Grid (GIG), and presents an alternative. This alternative provides value by applying smarter information management concepts to a typical mission profile. The JFCOM searches for technologies and ideas they can field to bridge the military services and achieve synergy among disparate sensor information in order to empower a networked force. Where should this effort begin and how long does the DoD have to investigate and institute technologies that will translate to real capabilities within the

battlespace? Clearly our potential rivals will not stand still and wait. They too seek better, faster ways to achieve victory in an increasingly networked world.

The current approach of pulling information may provide some level of benefit to the warfighter but will take a great deal of time to achieve. Even if the GIG and its pull approach to information access can be made to work, it may not provide the warfighter all the information he requires. This paper offers a solution to information delivery by identifying smart push as a better alternative to the current as-is situation in the field. This smart push delivery can be provided faster and incorporate pre-existing sensors. The best way to demonstrate the true benefits of smart push over current approaches lies in analyzing a use-case centered on a real mission scenario.

The use-case goes a long way in describing certain behaviors of a system or entity within a system. The actors within the use-case illustrate well the interaction of components and other actors within an event. The event in question stems from the view point of the main actor. The scenario considered in this paper centers around the Joint Terminal Attack Controller (JTAC) and a typical JTAC mission. By considering current technology employment in a JTAC mission and comparing it to a smart push alternative, the true benefits of the alternative become apparent. The JTAC scenario provides a very valuable use-case for a future demonstration or experimentation which will show in a measureable manner the true benefits from a hypothetical smart push of information.

By comparing approaches it becomes clear that the smart push of information offers the quickest way toward warrior support with the least amount of time. This thesis supports this view.

2. Joint Vision 2020

Joint Vision 2020 (JV2020) published by the Joint Chiefs of Staff in June of 2000 guides the military with the overall goal of “...the creation of a force that is dominant across the full spectrum of military operations – persuasive in peace, decisive in war, preeminent in any form of conflict.”¹ This presents a tall order. For some time now the

¹ Joint Chiefs of Staff, Joint Vision, 1.

United States has recognized the need to embark upon this journey of technological and cultural evolution. In 1986, President Reagan signed Public Law 99-433 most commonly known as the Goldwater-Nichols DoD Reorganization Act. This law gave more power to the Joint Chiefs of Staff and resolved the problem of a unified command of the services during joint combat. JV2020 recognizes that, “The integration of core competencies provided by the individual Services is essential to the joint team. To build the most effective force for 2020, we must be fully joint.”² What does being fully joint mean and how does the DoD take advantage of technology to make *jointness* a reality?

The mission of the military, fighting and winning our nations’ wars, has not changed. The means to accomplish the winning of wars now orients toward the military gaining and maintaining “full spectrum dominance.”³ The idea of full spectrum dominance “means the ability of U.S. forces, operating alone or with allies, to defeat any adversary and control any situation across the range of military operations.”⁴ So, while full spectrum dominance may be the goal, the *modus operandi* involves the military forging new capabilities centered around dominant maneuver, precision engagement, focused logistics and full dimensional protection. All of these capabilities include technology as an enabler. This increased use of technology leads to a focus on the network as an organizing principle for warfighting.

3. Network Centric Warfare/Operations

Martin van Creveld in his book *Command in War* stated the history of warfare demonstrates a keen interest in decreasing the “realm of uncertainty, resulting in a race between more information and the ability of technology to keep up with it.”⁵ This race continues today. NCW characterizes “the effective linking or networking of

² Joint Chiefs of Staff, Joint Vision, 3.

³ Ibid.

⁴ Jim Garamone, “Joint Vision 2020 Emphasizes Full Spectrum Dominance,” in American Forces Press DefenseLink.mil, 02 June 2000. <http://www.defenselink.mil/news/newsarticle.aspx?id=45289> Accessed January 2008.

⁵ Frank M. Snyder, *Command and Control: The Literature and Commentaries* (Washington D.C.: National Defense University Press, 1993), 148.

knowledgeable entities that are geographically or hierarchically dispersed. The networking of knowledgeable entities enables them to share information and collaborate to develop shared awareness, and also ... achieve self synchronization. The net result is increased combat power.”⁶ This increase in combat power comes in the form of shared battlespace awareness through ubiquitous interconnectivity and networking technologies. The use of a Common Operational Picture (COP) illustrates one aspect of NCW that will theoretically lead to victory through better, quicker decisions. However, technology alone cannot achieve such lofty goals. Successfully connecting all sensor information spread across the services does not automatically lead to results. These data must be utilized by decision makers and an acceptable decision must be reached. As a result, the push for NCW inside DoD does not simply involve the incorporation of new technology in the pursuit of improved capabilities but constitutes a new way of thinking. “Net Centric Operations (NCO) is the military embodiment of transformation. It is not about new weapons, new technologies, or new systems, although all of these need further development. Transformation is actually about changing values, attitudes, beliefs, and ultimately, behaviors.”⁷

The military’s realization that emphasis should no longer focus on parochial mission-specific platforms reflects revolutionary thought. The DoD must focus on networking people and processes to allow rapid knowledge sharing and decision-making. However, the latent tendency of each service to pursue its own idea of NCW continues. Indeed, each service adopted some form of what that particular service would term NCW. The Navy adopted a Cooperative Engagement Capability (CEC) which seeks to link sensor data from disparate platforms to form a common track capability. The Army adopted the Blue Force Tracker (BFT) as a method to track friendly or “blue” forces and the Marine Corps adopted its own form of BFT called Force 21 Base Command Brigade and Below (FBCB2). Interoperability of technology between the various services and U.S. allies appear to have received only marginal attention. This disparity may result

⁶ David S. Alberts, John J. Garstka, and Frederick P. Stein, *Network Centric Warfare*, 2d rev. ed. (Washington, D.C.: CCRP, 1999), 6-7.

⁷ John Gartska and David Alberts, *Network Centric Operations Conceptual Framework Version 2.0*; June 2004, 1.

from the Defense acquisition process where individual services control their own budgets with little effort made to align systems procurement with inter-service interoperability. Indeed within the same service, systems may not always operate well together. This tendency to acquire capabilities in a “stovepipe” fashion must be overcome and resisted.

If the inherent resistance within each service can be overcome and the DoD acquisition process modified, the true benefits from NCW might be realized. While an important topic for consideration, the intent of this thesis is not to investigate or offer a remedy for acquisition reform. While acquisition reform occupies the efforts of many within DoD, others have become focused on developing technology to increase accessibility and availability across multiple services. The current effort underway to accomplish this interoperability and availability within the DoD involves tagging all bits of information using terms defined by an Extensible Mark Up Language (XML) schema in order to facilitate easy access and pull of required information. Is this the best solution? This may *not* be the best approach.

a. XML

XML is a subset of the Standard Generalized Markup Language (SGML) and provides a ready means for expression and transmission of data. DoD wishes to mark up all data with XML tags formulated by Communities of Interest that would agree on the terminology and properties for each descriptive mark up. At first glance, XML tags appear a very good way of adopting a Net Centric approach to information delivery. If everyone agrees on how to label each data category and data element, it should be easy for a user to pull any information from the GIG using an appropriate search tool. The use of XML makes this approach seem even more attractive. The extensibility of XML allows developers to select and tag data based on the users’ requirements and modify these choices as needed. However, the monumental task of forming Communities of Interest and getting everyone to agree on a domain ontology to underlie the tags seems too large of a task to accomplish in a reasonable amount of time. This enterprise-wide approach, even if it can be made to work, will not render a capability tomorrow or even

five years from now. The better solution – find some way to adopt a “bottom up” approach that could be implemented within one to two years and yield results from the beginning.

b. Iterative Approach

If JFCOM could launch a software-based approach to information management that would yield positive warfighting results tomorrow, what value would this yield? In terms of actual dollars spent and capturing opportunities, it would be worth a great deal. If large projects cannot achieve their goals in a reasonable time, then the capabilities they may have afforded become diminished. Moreover, the opportunities of adopting technology faster, i.e. a faster, more agile force, have also been lost. Coupling the slow adoption of technology with current acquisition schedules of ten years or more constitutes a recipe for disaster. However, taking a page from DoD’s enterprise-wide approach, these Communities of Interest could be modified to form Communities of Practice formed around mission specific parameters.

JFCOM should consider high-risk, important missions and focus on these missions first. While it is clear that a perfect solution may not be generated from the outset, a software solution could be implemented that yields better information management without inflicting harm on the warfighter. Instead of attempting to get everything correct from the outset, an evolutionary or iterative approach could be adopted which will allow technology to get in the hands of the warfighter faster. Much like the spiral development methodology being embraced by the DoD acquisition community, a spiral approach to NCW information sharing could be adopted. Why attempt to tag everything up front? Why not attempt to classify missions deemed critical and start there. Or, better yet, find the “low hanging fruit” such as missions deemed critical which may be readily addressed.

The DoD has focused much attention lately on providing a Common Operational Picture (COP) to battlespace commanders. The boots on the ground have become a secondary focus. These frontline warriors don’t always require a COP, but

they do need information relevant to their current location and activities. An actual scenario can best explain how better information management could benefit the warfighter on the ground.

B. MISSION VALUE

The prototypical missions of securing a bridge or the taking of a hill illustrate well the fog of war. These missions appear simple exercises to implement but in the chaos of war, they become anything but simple. The events of March 23, 2003 in a little known province called An Nasiriyah, Iraq exemplify how better information management may have helped avoid fratricide.

1. An Nasiriyah Friendly Fire

Fratricide has existed in all wars and will continue to occur in the future. However, today's media environment and a public less inclined to accept fatalities greatly increases the damage done by fratricide. On March 23, 2003, a battalion of Marines tasked with securing two bridges over the Euphrates River and Saddam Canal came under attack. This Battalion included Bravo Company, the Forward Command Post, Alpha Company and Charlie Company. Bravo Company led the offensive across the southern bridge then left the main road to avoid enemy fire from what later became known as "ambush alley." Bravo Company, along with the Forward Command Post, subsequently got stuck in the mud and could no longer maneuver.

Due to pre-existing radio communications problems, Charlie Company falsely assumed Bravo Company had moved through ambush alley and taken the northern bridge. Charlie Company subsequently maneuvered across the southern bridge and moved through ambush alley where they began to take heavy fire. Charlie Company continued through ambush alley and took the northern bridge. Charlie Company then contacted the Battalion Commander (located with the Forward Command Post) and notified him of their position. A brief termination of enemy fire ensued. However, Charlie Company started to, once again, take heavy enemy fire. At the same time, the

Forward Air Controller (FAC) located with Bravo Company requested Close Air Support (CAS) to combat enemy forces attacking their position.

Two A-10 aircraft engaged the targets north of the canal. The A-10s arrived in the area and spotted damaged vehicles. The A-10 pilots, unfamiliar with Marine Corps vehicle silhouettes, erroneously reported the vehicles as enemy vehicles. In actuality, these damaged vehicles came from Charlie Company. The A-10s reported the sighting of these vehicles to the FAC who mistakenly verified the vehicles as the correct target. The FAC's erroneous verification resulted from observing smoke in the general area of the target. The FAC never actually saw target or the A-10s. Bravo Company, unable to verify other friendly force position, believed itself to be the lead element. This erroneous belief led them to conclude only hostile forces lay in front of them. The A-10 pilots received an erroneous report from the FAC stating no friendlies lay north of the southern bridge and gave the pilots clearance to engage. Due to the FAC's loss of Situational Awareness (SA) and misidentification of friendly forces as hostile, ten Marines died and four others were wounded.⁸

Numerous factors contributed to the loss of SA by the FAC. A few of these factors include the unplanned deviation from the planned scheme of maneuver, communication problems, and the actual hostile environment. The FAC also deviated from the Battalion Commander's standing orders on engagement with CAS. Specifically, the FAC utilizes three types of control when directing aircraft to engage. Type 1 is the default and means the FAC has "eyes on" the target. Type 2 control occurs when the FAC may not have an actual visual of the target but has a secondary visual through a UAV or some other means. Type 3 control is utilized when there is deemed a very low risk of fratricide, e.g., everything north of grid 20 is a target. Standing orders limited Type 3 control solely to the Battalion Commander. Therefore, the FAC utilized Type 3 control in violation of standing orders.

⁸ "Investigation of Suspected Friendly Fire Incident Near An Nasiriyah, Iraq, 23 March 2003." Globalsecurity.org. 29 March 2004 <http://www.globalsecurity.org/military/library/news/2002/11/mil-021108-centcom01.htm>. Accessed January 2008.

While the events leading to this tragic event appeared after careful analysis, what role did NCW play? This case presents a perfect example of how the fog of war and the threat of death can cause rash decisions to be made in the absence of critical information. Suppose a system existed that could provide real time information to the FAC or the pilots informing them of current friendly force position. Inserted correctly, Information Technology (IT) could have notified the FAC via some means that unit positions had changed. The pre-planned scheme of maneuver may have led the FAC to doubt the IT-provided updated positional data, but these data may have led him to refrain from calling in CAS on a position potentially containing friendly forces. This example also illustrates the difficulty in working in a joint environment. The Air Force pilots did not recognize the Marines' vehicles. If we take this example and amplify it, how would those same Air Force pilots be able to recognize coalition vehicles when they could not identify vehicles from their own armed forces? In this supposed NCW environment, these questions become critical.

The proposed DoD answer, the GIG, seeks to link myriad data sources with common XML tags each with an agreed upon definition. So how will this "pie in the sky" vision help the warfighter now? The answer, it won't. In fact, some troops on the ground view NCW as a buzzword. As a buzzword, NCW has no meaning. Worse yet, NCW may become viewed as a concept draining resources away from more valuable assets like people and equipment upgrades. In this one example from Iraq we see a 21st Century force still primarily utilizing basic communications technology, i.e. the radio, which has existed for generations. In short, while the DoD focuses on an enterprise-wide approach to technology adoption, the warfighter on the ground has become an afterthought. Technology should be adopted with the warfighter first and foremost in the minds of the DoD leadership. Actual practice has revealed this not to be the case.

a. Challenges

The various services must overcome parochial interests in order to adopt technology which unites force sensor and data information in order to increase battlespace effectiveness and increase capabilities. There will be resistance at all levels

as the services fall back on age-old suspicion and a parochial approach to war fighting. Moreover, the adoption of new technology will challenge the old forms of traditional command and control as well as doctrine and training. As DoD fuses sensor data and enables more real time force visibility, the inclination for high-ranking individuals to make decisions away from the battlefield must be resisted. An example would be a General Officer who can now see the entire battlespace and issues his commanders intent (CI). The battle ensues and conditions change. The personnel charged with carrying out the CI respond to the dynamic situation on the battlefield. The General, supposedly seeing the entire situation, must resist micro-managing the warfighters on the field and instead focus on the overarching battle scenario.

In addition to inter-service rivalry and the potential for commanders to micro-manage the battlespace, a need exists for joint thinking. The JFCOM calls this “thinking purple.” However, even if the cultural issues can be overcome and everyone starts “thinking purple” fusing disparate sensor information to deliver new and better capabilities in the battlespace quickly will continue to be a difficult challenge. If the vision of uniting this information can be achieved, how does the warfighter take full advantage of it? The scenario at An Nasiriyah serves as a good example. What information exists and how do you get required information to the warfighter when needed? The FAC required updated positional data on friendly and opposition forces in order to make a better decision on when and what to engage. How can a robust GIG provide this information to the warfighter? In its current iteration the GIG will not provide such required information in a timely fashion. However, there must be a way to implement technology in a way that provides a true increase in capabilities, sooner rather than later.

Utilization of limited bandwidth poses another problem that requires our attention. Stories in the media report Special Forces troops calling in air strikes with laser pointers. These stories seek to illustrate just how net centric the military has become. However, behind the scenes, “commanders had to queue up for the satellite uplinks and bickering broke out over who would get access to Unmanned Aerial Vehicles

(UAVs).”⁹ More recently, in November of 2007, the Army and the Air Force have squabbled over which service will organize UAV assets. Lt. Gen. David A. Deptula, deputy chief of staff for Information, Surveillance and Reconnaissance (ISR), currently heading up the ISR Concept of Operations (CONOPS) effort for the Air Force, stated: “we need to bring some unity to all ISR pieces for the combatant commanders (COCOMS).”¹⁰ Again, the problem with interservice rivalry rears its ugly head.

Bandwidth management, as a common problem among all services, will only continue to increase. If the GIG does indeed become successful allowing all pertinent information to become available in the info-space, how does the warfighter obtain what he needs when he needs it? When this large amount of information becomes available, the impact on bandwidth usage will be extreme. However, the GIG offers no real solution to bandwidth management. An alternative approach exists – adopt technology from the ground up centered on critical missions which will have an immediate impact. Deliver information smartly by providing only what the warfighter needs, when he needs it. Instead of insisting the warfighter pull information, have technology push information. The seminal works of Professor Hayes-Roth at the Naval Postgraduate School address this concept by developing the idea of Valued Information at the Right Time (VIRT). This approach presents an alternative and better way forward.

⁹ The Network is the Battlefield, Business Week Online, January 7, 2003.

¹⁰ Air Force Magazine Online, The Struggle Over UAVs by John A. Tirpak. November 2007, Vol. 90, No. 11.

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II. THE ALTERNATIVE

A. VIRT – VALUED INFORMATION AT THE RIGHT TIME

In the world envisioned by the GIG, all sensor information would be tagged in some meta-data model to allow for ease of access. Okay, great. Now what? Do we then develop a user interface much like Google on steroids in order to allow for quick access and delivery of that information? In other words, do we leave it to the warfighter to find what data may exist and how best to interface with it? If we go this route, how do we address the time value of information? How do we ensure a correct decision derives from timely and proper information? All these questions remain unanswered or postponed by the GIG. In fact, there exists an assumption that once everyone's sensor information becomes linked and given appropriate information tags, DoD will then be net-centric and better decisions will automatically follow. This incorrect and dangerous assumption belies the fact that too much information (often termed info-glut) can be equally deadly as too little information. So the question begs: How do you manage information smartly? The answer: VIRT.

VIRT acknowledges from the outset that while you cannot possibly know everything an individual may want or require, you do have a general idea of some things the individual will definitely want. A perfect example would be the Commanders Critical Information Requirements (CCIRs). The Commander lays down general orders to follow and if any significant delta occurs, he will be alerted so he can consider any new information or changing situation to formulate a new decision. VIRT utilizes technology in an automated way to do much the same thing.¹¹ An individual may make a plan based on certain assumptions, termed Conditions of Interest (COIs), if any of these COIs change, the plan may need modification. Technology, i.e. a Condition Monitor (CM) can be employed to monitor these assumptions in an automated fashion. The CM can be employed to monitor a myriad set of sensor information feeds, e.g., Blue Force Tracker.

¹¹ Rick Hayes-Roth, "Model Based Communication Networks and VIRT: Orders of Magnitude Better for Information Superiority," 2006.

This linking of sensor information means the condition monitor will continually check for any significant event, alerting the individual should one be found. This continuous query ability refers to a state-full approach where the system maintains and updates constantly the state or condition of each query. The entity will no longer need to complete a new query just to seek updated information. The system knows what the entity would like and continuously queries the available data for him. Figure 1 shows a simplistic view of this concept. The Dependency Monitor included in Figure 1 shows the interplay between a plan's assumptions and the information registry. This monitor, referred to earlier as a Condition Monitor, constantly looks for events and alerts the entity should one be discovered.

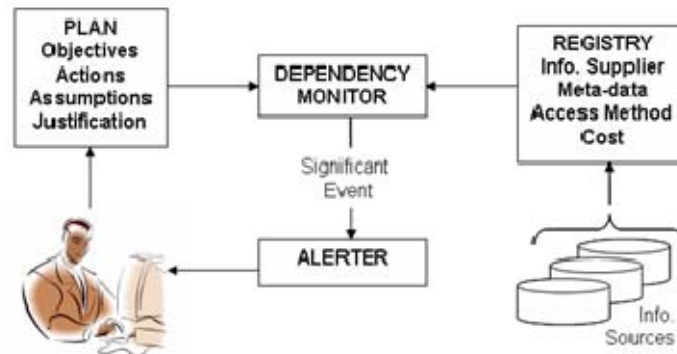


Figure 1. A simplified architecture for VIRT. (From: Hayes-Roth, 2006)

This VIRT methodology has, as its base, the idea that only some information has high value. The value of information delivered can be maximized by allowing technology to monitor conditions and only inform the individual when something of value has occurred. The individual may have a particular plan in mind. He can inform the system of this plan and let the system know what conditions to monitor that may have an impact on the plan. Instead of the individual having to repeatedly query the system to discover if any of his assumptions has changed, the Dependency Monitor now monitors these conditions for him. If any of the assumptions change, the alert goes out to the individual allowing the plan to be adjusted or cancelled. Professor Hayes-Roth has explicitly compared two alternative and idealized approaches to disseminating

information, which he termed Theories 1 and 2. In theory 1, each user pulls relevant data by periodically querying currently available data. In Theory 2, each user relies on a dependency monitor to continually scan for events of interest. VIRT, based on theory 2, seems clearly preferable in many situations.

1. Theory I: Google on Steroids

The first theory mirrors the current DoD approach of the GIG, namely, put the information out there and provide excellent query tools to pull the information down. This type of thinking stems from the belief that simply uniting information and having it available will engender information superiority. The events of September 11, 2001 may have led to this belief. Consider the example of Zacarias Maussaoui taking flight lessons in Minneapolis, Minnesota prior to September 11, 2001. The flight instructor became suspicious when Maussaoui showed no interest in learning to land the plane. The flight instructor notified the local FBI field office. The field office arrested Maussaoui in August of 2001 on immigration charges. This information, combined with other intelligence, may have thwarted the attacks of 9-11.¹² However, the need for this type connection did not occur until after the attacks.

After the attacks, many thought better decisions could result if a search ability existed across myriad agencies for similar information or intelligence. Thus the impetus grew to create a way that would make sense of all the information available and provide a way to access that information. The DoD pursued this approach by developing the GIG where all information would be tagged and therefore available to be pulled by anyone, from anywhere at anytime. Professor Hayes-Roth terms this “smart-pull.” This approach to networking assumes the individual needs to know information from a variety of sources and has the capabilities to query the system to obtain such information. If all disparate source data could be linked, the individual would only need a great search tool like Google to search out necessary information. Of course, this tool would need extreme robustness and responsiveness, becoming a “Google on steroids.”

¹² Newsmax.com. Congressman: FBI Ignored Repeated Warnings by Phil Brennan. December 24, 2001. Accessed January 2008.

This methodology can be termed state-less in that the information technology has no knowledge of what information may be required by the user or already known by him. The user simply queries the system for required information, the system provides that information and the communication is closed. This system does not maintain any knowledge of the “state” of the querying entity. For instance, an entity may query about the existence of a nuclear capability in a target country. The system initially reports, in our example, there is no known nuclear capability. The entity requesting the information accepts the report and formulates plans based on this information. However, shortly thereafter, the system may receive updated information that indicates the country in question does indeed have a nuclear capability. The stateless system, forgetting previous interactions, does not notify the last querying entity to let that entity know the change in information. The system simply updates its own database and leaves it to potential querying entities to discover it. Therefore the earlier entity making a decision based on the absence of a nuclear capability may be formulating a plan based on incorrect data. The entity won’t know the information has changed unless it poses a new query to the system.

2. Theory II: Smart Push Delivers Valued Info at the Right Time

Theory II adopts the idea where “each processing entity can describe conditions that would make its current plans undesirable, because those conditions would contradict assumptions needed to justify the choice of the affected plan.”¹³ With the increasing amounts of available information, technology must be utilized in a way to mitigate what humans experience as the “data glut”.¹⁴ It will not be sufficient for the DoD to concentrate on linking sensor data and publishing relevant information. The impetus must be on delivering information when and where necessary without placing the burden on the warfighter to “pull” required information or even to know the origin of the information. This becomes a critical concept. Information technology should be

¹³ Two Theories of Process Design for Information Superiority: Smart Pull vs. Smart Push. Rick Hayes-Roth, October 2005, 4. Available at http://www.dodccrp.org/events/2006_CCRTS/html/papers/010.pdf.

¹⁴ Ibid., 6

employed to bring the biggest bang for the buck to the warfighter as quickly as possible. Warfighters shouldn't need to be search and query experts. Warfighters want to utilize technology to manage information smartly and push pertinent changes about their assumed situations that may affect mission outcome.

This type of information management translates to a mission-specific application where the entity would specify certain conditions that, if negated, would warrant immediate notification. This is much like the CCIRs discussed earlier. Professor Hayes-Roth terms these Conditions of Interest (COIs). The “information network is tasked to monitor these COIs and to alert the operator immediately when one is detected.”¹⁵

3. VIRT: Simple Model Comparison

The simple models provided by Professor Hayes-Roth best clarify the differences between the two theories. Figures 2 and 3 below show the ideas of stateless and state-full processing, respectively. The two models may appear similar at first glance, but the fundamental way each approaches information delivery differs radically.

Simple model of Theory 1

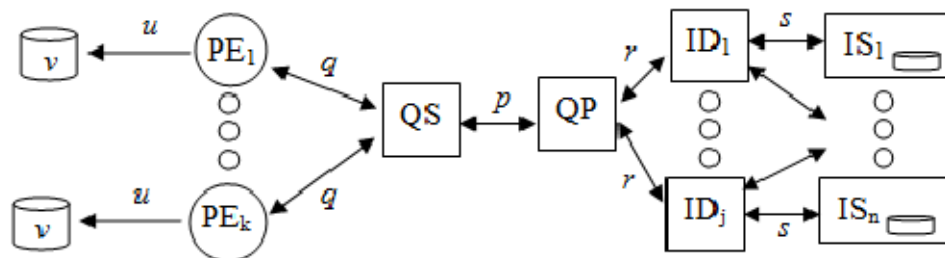


Figure 2. Theory I Model (From: Hayes-Roth, 2005)

By following the flow from left to right in Figure 2, it can be seen that the production of v or valued products flows from the Processing Entities (PEs) which do the actual work. These PEs query (q) the Query Specifier (QS) which, in turn, passes via transaction p to the Query Planner (QP). The QP utilizes any number of Information

¹⁵Two Theories of Process Design for Information Superiority: Smart Pull vs. Smart Push. Rick Hayes-Roth, October 2005, 4. Available at http://www.dodccrp.org/events/2006_CCRTS/html/papers/010.pdf

Directories (IDs) to discover what information may be available and how to access that information via process s . The Information Stores (IS) “...store, manage and access discrete bodies of information.”¹⁶ The relevant information flows back through the chain and is ultimately transformed into a valued product. Once the information reaches the PE, the query ceases and no further information is provided unless the PE provides a new query. Making a query in this state-less environment involves an apparent cheap use of bandwidth. The entity submits a query and the result is returned. The simplicity of approach and apparent low cost communication makes this approach attractive.

Simple model of Theory 2

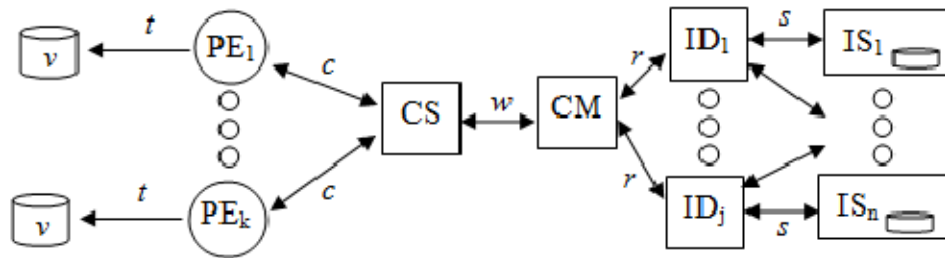


Figure 3. Theory II Model (From: Hayes-Roth, 2005)

The second model does not simply revise the first model with new letters. This model shows VIRT in action. Each PE specifies its informational requirement conditions c to the Condition Specifier (CS). These conditions are relayed to the Condition Monitor (CM) via transactions w . The CM accepts these conditions and discovers through the IDs and ISs what information is available and how to access it. If a change occurs in the data matching the conditions specified, the CM will report these events back to the PE through the CS which in turn produces the valued product. The main idea revolves around the constant state-full approach of the CM. The CM monitors all available informational resources continuously and reports back any changed data corresponding to events matching the specified conditions.

Clearly the use of a CM poses the great potential of decreasing bandwidth resources by providing only the information deemed valuable by the PE. This approach

¹⁶ Rick Hayes-Roth, “Two Theories of Process Design for Information Superiority: Smart Pull vs. Smart Push,” October 2005, 7.

also relieves the PE of constantly forming new queries each and every time the PE would like an information update. These conditions can be translated well into the vernacular relevant to the PE. VIRT conforms well to current operations because the language utilized to define COIs may be based on the vocabulary of the operators themselves. Therefore, the operators do not need to learn a new language to interact with the system, they simply set up their COIs using a vocabulary familiar to them. The state-full COIs continuously monitor these identified conditions via brokers or agents and report any relevant change. If applied successfully, the operator would not need to waste time digesting immaterial routine data, e.g., insignificant weather updates. On the other hand, if the weather changes in a way that can significantly affect the mission, the system will alert him. Just in Time (JIT) inventory practices compare well to the smart delivery of information. Both concentrate on the delivery of only those items deemed necessary or valuable.

B. SUPPLY CHAIN – A SIMILAR APPROACH

The world has witnessed numerous innovations within the commercial sector involving inventory management. The concept of Just-in-Time (JIT) has caught on and offers a great solution to the problem of too much inventory leading to the large costs associated with storage. The relevance of the delivery of products or raw material compares well to the smart delivery of information. JIT relies on physical inventory control queues referred to by the Japanese name of *kanban* to signal the need to move raw materials from a previous process to a new one. There exists a great similarity between JIT and the VIRT concept of continuous query for new significant events. Where one moves valuable molecules, the other moves valued bits. The CM continuously queries the system and if one of its conditions has changed, a signal will notify the PE of a change in identified conditions.

Suppliers of raw materials interface closely with their customers to implement kanban systems that provide instant notification of a requirement so the supplier can fulfill a need. This customer-supplier interface seeks to reduce or eliminate waste or what the Japanese call *muda* from their system. Lean systems employed by companies

all over the world focus on the elimination of this muda. By focusing on the elimination of waste, the supplier can avoid costly over-production, unnecessary work in process (WIP) and unnecessary inventory. Lean systems fit well the current effort within DoD to find a way to better manage the limited bandwidth available in an operational environment. The ever-increasing amount of information has made proper bandwidth management of increasing concern. A great deal of current research focuses on increasing bandwidth on the battlefield. However, research concentrating on better ways to manage current available bandwidth lag. VIRT offers a solution. The use of available bandwidth can be significantly reduced if only information deemed valuable is delivered. Instead of the current approach of delivering a COP to every user, a better concept would be a User Defined Operating Picture (UDOP) supplied by VIRT smart push. In this UDOP, COIs are identified and when bandwidth becomes limited, only pertinent, valued information would be delivered.

The production environment does not want to waste resources manufacturing products that will not be used or shipping raw materials which will sit idly in a warehouse. That environment wishes to ship only products or raw materials of immediate use. This focus on shipping value aligns well with the VIRT idea of utilizing bandwidth to only ship information (bits) deemed valuable. VIRT poses the question, “Why waste valuable resources shipping redundant or unimportant information if we can avoid it?” Moreover, the human operator can only effectively process limited amounts of information. Deluging a human with too much information may lead to paralysis or, at the very least, much slower decisions. Technology can be utilized to actively monitor sensor and other information sources to glean value and deliver information to the human when and where needed. This information will not only be what the human wants exactly, it will also be the most up to date and relevant information the system has to offer. Thus, instead of information withering on the vine it will be selectively plucked and effectively consumed.

While not addressing VIRT *per se*, some efforts in DoD provide a potential basis for rapidly launching VIRT. In particular, we want to consider efforts within DoD that

focus on machine-to-machine communication. One of these, called Cursor on Target (CoT), highlights a central focus on delivering necessary information, e.g., sensor data, where and when required.

C. CURSOR ON TARGET

Cursor on Target attempts to solve the problem of interoperability by focusing on replacing the “human voice and physical interface needed when combat controllers in the field transmit targeting data.”¹⁷ Replacing the human in the loop with Machine to Machine (M2M) communication will reduce lag time and human-induced error. The ultimate goal will “allow all the necessary information and tasking orders to flow to the target as needed when command center personnel literally put their computer cursor over the target.”¹⁸ The idea of putting a cursor over a target and having all the information flow comes from the mind of Air Force Chief of Staff General John Jumper who, in a 2003 conference, stated “we’ve got to learn to think in terms of integration so that the sum of the systems all put together between air, land, sea and space, ends up with a cursor over the target.”¹⁹

The Air Force Materiel Commands (AFMC) Electronic Systems Center (ESC) took General Jumper’s challenge to heart and selected MITRE Corporation to lead the effort. This eventually led to the production of several prototype activities with more than 40 different systems throughout the military. They utilized the commercial viability of XML but not in a top-down way. They used XML as an enabler focusing on the what, where and when. The CoT effort has led to M2M targeting to:

¹⁷ Cursor on Target information technology online, by William Miller. Article published September 2, 2004, Volume 8 Issue 7. <http://www.military-information-technology.com/article.cfm?DocID=596> Accessed February 2008.

¹⁸Cursor on Target information technology online, by William Miller. Article published September 02, 2004, Volume 8 Issue 7. <http://www.military-information-technology.com/article.cfm?DocID=596> Accessed February 2008.

¹⁹ Space Architecture and Integration – Challenges for the Future – Transcript. Speech to the 19th National Space Symposium, Colorado Springs, Colo., April 10, 2003. Available at bnet.com http://findarticles.com/p/articles/mi_m0PDU/is_2003_April_10/ai_109569811 Accessed February 2008.

- provide special forces the ability to click on a laser rangefinder designating a hostile target,
- pass precision coordinates,
- send mensurated target coordinates to an airborne asset, and
- download these directly into a GPS-guided munition.²⁰

This M2M linking may benefit from an additional insertion of the human as a producer and consumer of linked information. This new *prosumer* would be able to link into the M2M world to gain valuable sensor data. A VIRT type technology could be inserted to monitor information in accordance with COIs and deliver valued information to the human. The Air Force may think future warfare will evolve into a simple computer game played by personnel stationed in the United States. This idea may indeed prove true in the future, but the here and now leaves little doubt that the warfighter on the ground will continue to remain at the tip of spear. This warrior can well benefit from such technology today. Why wait years when we can implement a system to fuse myriad M2M sensor information and filter such information in a humanly usable way? The answer: we shouldn't.

The fusing of machines into a viable shared awareness cannot leave the frontline warrior out of the picture. The warrior on the ground can benefit more from sensor information in the formulation of tactics and actual mission planning than anyone. VIRT concepts would allow this warrior to identify information important to him and choose how to be alerted if any of the assumptions in his world view should change in a pre-defined, significant way. Coupling VIRT with a CoT capability shows a great deal of promise in delivering this type of capability within a few months instead of a few decades.

The effectiveness of the VIRT concept can be best illustrated when applied to a typical mission. As illustrated earlier in this paper, the CAS mission holds a great deal of promise for technology insertion. The goals of CAS seek to concentrate air assets to

²⁰ Mitre Corporation, "Cursor on Target Narrative" (Bedford, Massachusetts: 2007, photocopied), 1.

destroy enemy positions while minimizing or avoiding fratricide and civilian casualties. The incident at An Nasiriyah illustrates an example of the real risk of fratricide in maneuver warfare. The JFCOM has adopted the idea of a Joint Terminal Attack Controller (JTAC) who can control the air assets of any service. The JTAC extends the Marine and Air Force Forward Air Controller (FAC) concept. Analyzing the current process of information delivery or the “as-is” and comparing it to Theory II, or Smart Push, will help identify the strengths and weaknesses of each. A brief overview of the JTAC mission follows.

D. THE APPLICATION: JOINT TERMINAL ATTACK CONTROLLER

Joint Publication 1-02 defines a JTAC as:

A qualified (certified) Service member who, from a forward position, directs the action of combat aircraft engaged in close air support and other offensive air operations. A qualified and current JTAC will be recognized across the Department of Defense as capable and authorized to perform terminal attack control.

This amounts to a sort of “driver’s license” or credentialization for the ground-based FACs from all services. This definition disguises the true difficulty in accomplishing such a daunting mission. “The job of the JTAC includes control, de-confliction, respecting availability times, clearing aircraft off to tankers, and so forth.”²¹ This type of control applies to all service aircraft. This JTAC mission seems a perfect case for the incorporation of inter-service sensor fusion and VIRT concepts. Already the importance of the JTAC mission has proven important enough for the respective services to accept a common, joint training and evaluation standard that applies across the components.²²

The importance of this mission reflects the great amount of effort taken to link the services to form a common training environment. The reason for this focus stems from

²¹ Rebecca Grant, “Bombs on Target,” Airforce Magazine Online Volume 88, No. 8 (August 2005). Available at < <http://www.afa.org/magazine/aug2005/0805target.asp>>. Accessed January 2008.

²² Robert G. Armfield, JTAC: Separating Fact from Fiction (Alabama: Air Command and Staff College Air University, 2003), 7.

the extreme desire to avoid fratricide and enable air controllers from the various services to control all air assets as needed. The need for a JTAC came partly out of Operation ALLIED FORCE when in the summer of 2000, Air Force combat controllers had their qualification as TACs questioned. This led the Air Force to seek an acceptable joint qualification which would be accepted by all the services. After Operation ANACONDA, the Army showed great interest in the JTAC concept. Conducted in March of 2002, operation ANACONDA showed the U.S. Army ground forces working closely with several allies and their sister services. Operation ANACONDA revealed a need to de-conflict air space and provide coordinated air control. The Army subsequently saw a need for up to 1000 JTACs. This led to the November 2002 effort by the Joint Chiefs of Staff (JCS) to establish a Joint Close Air Support (JCAS) Executive Steering Committee. A common training standard and qualification for JTACs, outlined in Joint Publication 3-09, resulted. It should be re-emphasized here that this important change occurred from the ground or bottom up. The warriors on the ground saw the need where those above did not. Once they identified the need of CAS coordination, they began searching for a solution.

Introduced and adopted quickly, the JTAC concept reflected the urgent need for this type of qualified individual. However, the services cannot fall into the trap of creating a whole battalion of JTACs with a belief that this alone will resolve the issue of fratricide and enable better unity of force. Indeed, this effort may very well have the opposite effect. If numerous JTACs take to the field, there exists the real possibility of multiple kinetic responses to the same target. For example, if two JTACs operating in adjacent areas hear a radio call from an isolated force to render CAS, each of these JTACs may independently begin coordinating fire with their assigned assets on the necessary position when one engagement would suffice. Therefore, the JTAC in charge of overall operational deconfliction will have a much harder job in airspace deconfliction and target acquisition. This wastes manpower and ammunition and increases the possibility of fratricide. As the number of certified JTACs increase, the DoD must look for better ways to coordinate their activities. Obviously voice alone will not suffice. If

the number of JTACs increase without a better use of technology to facilitate clear communications, an already overburdened voice communications infrastructure may become useless.

As shown by the quickly adopted JTAC concept, the warriors on the frontline will not wait for direction from above to make things happen. The ethos of the warrior leads him to demand solutions to existing problems now. This presents a perfect opportunity to introduce the concept of VIRT fused with a CoT technology linking sensor data in order to provide better SA with intelligent signaling to decrease bandwidth usage while increasing unity of force.

The JTAC role in planned and emergency on-call CAS may involve a great deal of different scenarios. Chapter III of this thesis illustrates a scenario a JTAC may well find himself in. While hypothetical, the scenario illustrates well the usefulness of the VIRT concept.

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III. THE SCENARIO

A. JTAC OPERATIONAL SCENARIO

1. The Model

While no “typical” JTAC scenario exists in the operational environment, the following scenario serves as a realistic example. The mission below flows from planning through execution. The basis of the scenario revolves around the USMC experience. In the operational environment, the Maneuvering Commanding Officer (CO) owns the operational environment in which the JTAC operates. The CO will generate an order that turns into a local order tasking a unit the JTAC belongs to. The exemplar task: destroy a house containing opposition forces (OPFOR). This explosion will signal other friendly forces to commence ingress into a northern position.

The JTAC will evaluate the mission and determine what assets he requires to neutralize the target. The JTAC also needs to know the placement of pre-existing kinetic assets. Assets in place may include mortars and artillery that could be planned into the mission. The JTAC will plot the location of all indirect fire assets so he can ensure airspace de-confliction. This pre-planning may include allowance for Naval Surface Fire Support (NSFS) assets located offshore or artillery batteries. For this example, the JTAC decides an F-18 loaded with a 500 lb bomb will suffice to neutralize the target while negating the possibility of fratricide. His assigned area encompasses roughly 2 sq km and involves land, air and temporal conditions. Once the JTAC determines the assets necessary to fulfill the mission task, he submits his requirements up the air chain of command in the form of a JTAR (Joint Tactical Air Request). A pre-planned mission is normally submitted 96 hours prior to mission date. Those requests submitted less than 96 hours, termed immediate requests, should be sufficiently important to justify the shuffling of assets. For instance, immediate requests can be submitted for a “right now” situation, in which case a section in the air or on the flight line can be re-tasked from their assigned mission to support the JTAC’s more vital mission. This request is filtered and subsequently included in the Air Tasking Order (ATO) – often taking 24 hours or more to generate.

Once the ATO comes out, the JTAC discovers whether the requested assets have been approved and if not, what assigned assets he has to work with. This may require a modification of the JTAC's plan. For instance maybe one potential delivery platform, the AC-130H, is unavailable for the time of the planned attack, but an F-18 is available. Or the available ordnance may not include the preferred 500 lb bomb. In this scenario, we'll assume the requested assets (a 500 lb bomb and precision delivery via F-18) remain available and assigned.

The JTAC and his team detach to the Observation Position (OP). From this vantage they may put eyes on the target. The F-18 checks in with the JTAC who then assumes control. The initial exchange between the pilot and the JTAC most often involves a brief summary by the JTAC to bring the pilot up to speed on the ground situation and to ensure both pilot and JTAC perceive the same target. This initial exchange will also include aircraft call sign, type, ordnance available, time on station (TOS), and current position (including the assigned airspace or "chunk of sky" that the aircraft is allowed in). This may include requesting the pilot to make use of his targeting pod (if the aircraft is equipped) to put eyes on the target. If the JTAC is carrying a Rover ground station, he can look at the video feed to ensure the pilot is, indeed, targeting the correct position. While not always the case, a Rover partnered with a targeting pod provides the JTAC a great deal of comfort because he knows with almost absolute certainty the target is correct because he sees exactly what the pilot sees.

2. Basic Mission

Intelligence reports a particular house contains terrorists. The area commander orders a daytime assault on the house and surrounding community. The attack shall rally a larger assault on the area. Assigned to loiter in the area, a UAV Scan Eagle will remain at an altitude of 5000 feet. The JTAC must track the position of this asset. A Rover will deliver the video feed to the JTAC. The JTAC can only view one feed at a time but the HQ can watch any number of feeds and reports by voice to the field JTAC.

The success of the mission shall be determined by a Battle Damage Assessment (BDA) conducted by the JTAC. The F-18 reports on station and information is relayed to

the pilot. The target house is confirmed by the targeting pod. The F-18 drops its ordnance and egresses out of the area via pre-planned route. The bombardment of the house initiates friendly troop movement north. Subsequently, the Scan Eagle reports video to HQ of a truck moving at high speed toward the JTAC's area. Intel reports this vehicle contains terrorists retreating from a nearby operational area engagement. HQ orders the JTAC to engage and destroy the fleeing truck.

Unit Standard Operating Procedure (SOP) states a UAV can provide the JTAC Type II control. Since the JTAC does not have a visual, he declares Type II control with the AC-130 Gunship asset. At the same time the JTAC spots an unanticipated UH-60Q Medical Evacuation (medevac) helicopter (helo) transiting through the area. This unanticipated air movement causes him to cancel the truck engagement with the AC-130. The AC-130 can no longer remain on station and returns to base (RTB) due to bingo fuel (only enough fuel to return to base). Once the helo clears the area, the AC-130 asset has moved out of the area and the JTAC requests another asset through his air officer at HQ. The Air Officer has anticipated the bingo fuel and the resultant request and has a nearby Cobra directed to support the JTAC. The JTAC utilizes the UAV asset under Type II control to track the target and talk the pilot to it. The Cobra engages the moving truck and destroys it. UAV loitering provides BDA indicating the initial target and truck target destroyed. Blue Forces continue movement North into another AOR. JTAC stays in current AOR.

The JTAC has a complex task. He must monitor and track all air assets within his AOR as well as the location of other types of fire whether on the ground or at sea. He must also monitor the location of friendly forces as well as the location of the bad guys. The situation on the ground constantly evolves. Tracking all of this information taxes the JTAC and increases the potential for mistakes.²³

²³ Capt. Byron Harder, USMC of Monterey, interview by author, 27 November 2007, Monterey, personal notes, Naval Postgraduate School, Monterey, CA

3. Phases of JTAC Engagement

The ability of the JTAC to call off the aircraft from a bombing run will depend on the current aircraft phase of attack. The five phases include:

1. Phase 1 – Check-in: Aircraft holding on station and JTAC delivers 9-line report. This report contains the initial point/battle position, heading, distance, target elevation, target description, target location, type mark, location of friendlies, and egress.²⁴
2. Phase II – Preparation: This phase occurs between the 9-line report and the actual commencement of the attack run. Usually 1 – 2 minutes elapse before time on target (TOT).
3. Phase III – Attack Inbound Phase: Aircraft departs the check in point and arrives at the initial point (IP).
4. Phase IV – Attack Phase: This begins at the IP and continues until the target has been prosecuted. The JTAC will hear an “IP Inbound” report from the pilot. The pilot will be waiting for the JTAC to report “cleared hot.” If the pilot does not receive a “cleared hot” report, the pilot will report “wings level.” If a “cleared hot” report is still not received, the pilot will vector off and report his call sign and “no drop.”
5. Phase V – Egress Phase: Aircraft headed back to Control Point (CP).²⁵

4. Possible COIs

Weapons status and aircraft ordnance carried suggest a few of the several instances a condition monitor (CM) could usefully track. A case could exist where the JTAC anticipates the use of a 500 lb bomb. When the pilot checks in, he might report to the JTAC the unavailability of any 500 lb bombs. As a result, the aircraft carries a 1,000 lb bomb as replacement. In its anticipated application, the JTAC could realize that the damage radius of the 1000 lb bomb would make fratricide unavoidable. Thus, the JTAC realizes the available ordnance cannot be utilized in this situation. This may be a go/no-go decision. Wouldn't it be nice if the JTAC knew earlier that the aircraft assigned to him is not carrying the ordnance he thinks essential? Shouldn't he be informed before

²⁴ JFIRE Multi Service Procedures for the Joint Application of Fire Power, October 2004

²⁵ Capt Byron Harder, USMC. Interview conducted 13 February 2008. These are not official phases, but general categories of aircraft engagement as perceived by Capt Harder.

the aircraft takes off instead of when the aircraft arrives and checks in with him? This type of event could be monitored for him, and alerting him to the event would deliver high value in a timely way.

Another opportunity for detecting events would result from monitoring the surrounding area. Any unexpected traffic reported moving towards his area should initiate an alert. This could be done via automated means instead of requiring constant human-in-the-loop radio feed as now done. COI examples include:

- Unanticipated medevac aircraft appears in AOR. Need to know in order to avoid potential fratricide and airspace conflict.
- Blue force movement not as briefed in the pre-planned scheme of maneuver – any unanticipated change in location is forwarded.
- New intelligence reports civilians in the area, which may mean mission no-go.
- Fuel status of assigned assets (including replacement assets should bingo fuel require assigned assets to return to base.)

These COIs can be generalized as shown in Table 1.

COI Instance	COI Generalized Pattern
Unplanned medevac helo comes within 2km of any airborne gunships at any time during the medevac mission	...at any time (t), distance(position(non_combatant(t)), position(gunship_combatant(t)) < safe threshold
Assigned aircraft fuel requirements insufficient for mission completion (including reserve)	...at any time (t) remaining_resource(Res, Agent, Plan, Route, Position (t)) < resource_needed_to_complete(Res, Agent, Plan, Route, Position(t)) + safety_reserve (Res, Agent, Plan)
New intel reports unplanned civilians in AOR. If UAV asset confirms, send visual.	...at any time (t), : non-combatant(nc).position(t) is_inside my.AOR(t) & visually_verified(nc, "Civilian," UAV.camera.feed(position(t), t)
Blue force position changes from planned scheme of maneuver.	...at any time (t), distance (blue force position(t), (blueforce planned position(t)) > position-delta- threshold

Table 1. COI Table

B. JTAC AS-IS: ASSUMPTIONS AND LIMITATIONS OF THE SCENARIO

1. Assumptions

Communications will remain intact for the entirety of the mission. The interconnectivity of sensor information will be continuous. The incoming medevac helicopter position will not be available until too late for diversion instructions. The medevac mission takes priority over the JTACs mission.

2. Limitations

This scenario involves a limited set of interactive assets. This constriction of assets and scope of the scenario results from the limited amount of sensor information that can be readily simulated in an academic environment. This scenario will be used as the basis for an experiment combining limited sensor resources to provide a means of comparison between the current approach to information delivery and the Theory 2 or VIRT approach. However, even though the scope of the experiment may be limited, the efficacy of the VIRT approach may still prove itself. Therefore, the only items being continually monitored will be those items the system can currently link with via M2M interface.

Since all assets in the scenario lack a common link and cannot share data automatically, e.g., fuel status, weapons payload, etc., the power of their union cannot be illustrated. An example would be the power of uniting weapons payload data via automated interface with the aircraft data as soon as the aircraft lifts off. This would update JTAC information and allow a change in plans, if necessary, prior to the aircraft arriving on station. In a perfect world, all assets would have some level of an automated information generation capability and this information would feed various condition monitors throughout the battlespace.

The informational load will be limited to the field level JTAC in this scenario. While it becomes apparent that the central JTAC may also be overloaded with information, that complexity is not addressed in this basic view. However, application of

the VIRT concept can be expanded in the future to include the central JTAC as well as other humans in the loop such as the battalion commander (or the pilot).

The JTAC's main communication method revolves around a voice link over a UHF, VHF, and UHF Satcom PRC-117F radio. Current position of forces may be available through BFT. However, the JTAC receives positional updates as deemed necessary by a central JTAC located in a safe position coordinating the efforts of several JTACs in the field. This coordination effort requires a great deal of mental effort to maintain real-time SA. It cannot be assumed that all pertinent friendly force positional changes or updated sensor information will be relayed in a timely manner to personnel in the field. The processing entity, in this case a human, has a limited cognitive ability to process large amounts of information.

Some of the current information requirements of the field level JTAC include:

- Position of friendly and opposition forces updated as they change. This is especially important prior to CAS employment.
- Planned times of mortar and NSFS fire as well as the vectors these fires will use and the ultimate target of each. This is necessary to de-conflict airspace.
- Maneuver boundaries.
- The assigned altitude blocks for each aircraft.
- The target assigned to each aircraft.
- Actual location of each aircraft.
- The ordnance located on each aircraft.
- Unit boundaries (updated if they change)

A myriad of sources may contain this information but the current JTAC has difficulty accessing them easily. As a result, information gathering becomes burdensome and time consuming. However, the JTAC considers this information critical to proper decision-making. For example, the location of friendly forces concerns the JTAC

greatly. He needs to know immediately if force positions change in any way that will affect his mission. If troops move into his AOR and specifically into his current target location, these forces may become collateral damage. Of near equal importance, the location of civilian non-combatants needs to be known as soon as possible. If the JTAC engages a target and successfully destroys it but in the process kills several women and children, the otherwise successful operation turns into a failure.

The ordnance an aircraft carries is of great importance and relates to the earlier point of fratricide and civilian casualties. If an assigned aircraft expects to carry a 500 lb bomb but instead carries a 1000 lb bomb, the JTAC will need to reconsider whether the target can be engaged with the larger ordnance. This consideration depends on whether the increase in kinetic force will impact the safety of nearby forces or neutral parties. If the ordnance does not pair well with the target, the mission may be canceled. If the JTAC does not find out this information until the aircraft checks in with him, he must scramble to locate other assets to divert to his mission. Moreover, his mission may not be a high priority and will be cancelled. This wastes resources.

In the hypothetical scenario mentioned in this paper, the JTAC must receive information in a piecemeal fashion. He creates a plan and submits this plan for acceptance into the ATO. Once approved, he deploys to the OP and readies himself for the mission. At least three radio operators accompany the JTAC. He carries a great deal of weight and coordinates his efforts with numerous parties. Since his main concern lies with the aircraft assigned to carry out his mission, he establishes contact with the pilot and relays any change in information and confirms the plan of attack.

The amount of voice relay of information becomes quite large over time and the dynamically changing situation on the ground (and in the air) causes the JTAC to necessarily focus on the one mission at hand. Sometimes, a pilot is so overwhelmed with chatter that he will turn down the radio when he is in the midst of a bombing run so he can focus better. The bits of information in this as-is example do not represent the total amount of information the JTAC must process. However, this example does hint at the deluge of information and how technology may not be helping him to the extent it could. The UAV video and the targeting pod video have become very useful tools allowing the

JTAC to engage a target better and with more clarity. However, this simply represents new technology gathering and dissemination. The human must still compile and analyze this information and make decisions quickly. The types of information the UAV and targeting pods represent will increase in the future. Therefore, technology must be employed in such a way to make better sense of the deluge and still deliver valuable information when and where needed.

C. VIRT VERSUS AS-IS JTAC SCENARIO: A VALUABLE COMPARISON

The primary method the JTAC utilizes for information delivery relies heavily on voice communications. Any updated information must be passed directly to the JTAC in the field via several voice channels. The JTAC and two or three other radio personnel monitor these voice channels. These personnel help the JTAC ensure he has an excellent overall situational awareness. However, this over-reliance on voice technology causes a problem of excessive “chatter” limiting the amount of information passed. Furthermore, there exists information in the battlespace not currently utilized that would significantly enhance the JTACs mission effectiveness. This information includes the position of opposition forces, new intelligence reports of civilian positions, IED positional data reported from the field, fuel status of incoming aircraft, directional indicators of flight paths through the JTACs AOR, aircraft payloads, etc. This dynamically changing information would greatly benefit the JTAC in the field. Prior to a specific mission a situation report (SITREP) may be analyzed that details much of this information. However, changes in this SITREP may not be reported to the JTAC once he has departed the HQ. These changes may have a significant impact on mission success. Therefore, the JTAC requires this new information in order to re-evaluate mission assumptions. If these changes can be delivered in a real-time, non-burdensome way, the effectiveness of the JTAC can be greatly enhanced. A few ways exist to accomplish the goal of smart information delivery.

The current approach of radio-voice communications and human-in-the-loop information dissemination presents a base case. This approach offers the benefit of a force structure currently in place familiar with this type of information delivery.

However, this approach also presents an exponential problem of scalability. The amounts of available information will no doubt increase to a level not currently imaginable. The archaic use of voice technology cannot possibly keep pace with this rapid increase. Furthermore, voice communications does not currently allow an automated system to check machine-originated information resources and deliver them smartly to the warfighter. An example would be the monitoring of an aircraft's fuel state. Technology already exists that monitors aircraft fuel status. The sooner the JTAC becomes aware that available fuel may not meet mission requirements the sooner he can alter the plan as necessary. The current approach cannot harness this type of information delivery without hiring more soldiers to monitor fuel status and make aural reports. The DoD acknowledges the significance of this information increase and offers a solution centered around the smart pull of information over the GIG. This type of information pull will not be adequate.

In the world envisioned by the GIG, warriors will subscribe to informational nodes, and information will then be forwarded to the warrior according to subscribed communities. This approach places the impetus on the warrior to know what sources exist and constantly check the availability of any new information. The system will allow the user to form a standing query but does not allow the type of precise specifications as a CM would address. This unparsed information would require the warfighter to orient the information to the current situation. While this approach offers some level of value, it does not address real mission-specific implementation of technology to allow the warrior on the ground to fully maximize available information.

Currently, the JTAC has numerous tasks he must accomplish. Maintaining situational awareness remains the primary task of the JTAC requiring much of his attention and concentration. The JTAC must monitor the projected flight paths of all aircraft within his AOR and ensure there is no intersection. He must monitor the position of friendly forces, opposition forces, civilians, bomb payloads, unplanned force movement, etc. Moreover, he must coordinate with each aircraft as they approach their targets to ensure proper engagement. Subsequently, he must conduct a BDA to ensure target destruction. Battlespace knowledge includes monitoring of artillery naval surface

fire origination and destination. In short, the JTAC must consider a great deal of information. As a result, the smartest JTAC can become overwhelmed with the current load of information. In the coming years, this information will only increase. Technology must be better employed to deliver information smartly otherwise the JTAC may become overwhelmed. In short, without something that smartly reduces the volume of relevant information, the JTAC of tomorrow will risk paralysis by analysis.

The increase in information coupled with bandwidth limitations presents a challenge to DoD. If the DoD continues with the current approach to battlefield information management, the warfighter on the ground may find available bandwidth quickly overwhelmed. If the GIG becomes a ubiquitous reality, there will be a great increase in users accessing all types of information from the field. While the cost of each individual query may not be large, the aggregate total of all these new queries may overtax the IT infrastructure. This could remain true even assuming a large growth in available bandwidth. For example, the person making a query in the field may not know the exact information required. He enters a query and the system returns numerous items which may be relevant. This approach mirrors Google's client-query response. Now, imagine the warfighter wants a UAV video centered around his AOR. First, he must enter a search. The search may not find a UAV centered around his AOR; however there may be several feeds from nearby areas. If the system returns these feeds, the infrastructure may function acceptably until such time as several other queries attempt to deliver video feed as well.

Clearly, transforming warfighters into information query experts may not be the best solution, especially when these warriors find themselves in harm's way. Moreover, the resistance from the warfighter may be extreme. These individuals do not want their lives made more difficult. This type of technology implementation would undoubtedly become more burdensome because the onus of information gathering would be placed on the warriors' shoulders. Instead, information technology and the ever increasing power of computational capability should be harnessed to do much of this monitoring for the warrior and only deliver to him what is pertinent to his situation. This smart IT filter in the form of VIRT will gather much more information from many more sources and boil it

down to usable pieces of timely information delivered to the warfighter when and where needed. Additionally, since the IT system will filter the information according to the user's input and the actual information filtering occurs as close as possible to the actual information source, the amount of bandwidth utilized to deliver this information decreases. This decrease in bandwidth usage results from the IT system only utilizing enough bandwidth necessary to deliver pertinent changes. Thus, the channels remain unclogged even with numerous users attempting to pull down information simultaneously. Subsequently, information delivery only occurs when necessary.

In a VIRT application, the operator or the Decision Support System (DSS) working on behalf of the operator, defines the required information. Therefore, the JTAC, for example, will employ technology to filter information he deems important and determine the delivery method alerts will be sent. The operator identifies COIs and loads them into the system. Pre-loaded COIs can exist within the system based on a similar users previous experience. This presents a powerful way to harness lessons learned and continuous improvement. The beta version of this VIRT system may not have a robust set of COIs, so the user will probably need to refine them. However, once entered, the system will retain these conditions and pre-load them the next time a similar user accesses the system. Some of these COIs may not function well and might need to be modified. A new JTAC in the field, for example, may not know exactly what he should ask the system to deliver. Over time the system will have interacted with numerous JTACs and will possess a very good inventory of what a typical JTAC will need to know. The new JTAC will enter his area of operations and assigned aircraft. The system will then be able to tell him what it will monitor and offer an opportunity to modify or add other COIs. This results in a more effective JTAC on day one of his tour.

Theory II involves a more conceptual approach. The "blackbox" containing a VIRT condition monitor will need to interface with current Intelligence, Surveillance and Reconnaissance (ISR) assets. Moreover, several databases will need to be connected in order to store relevant data including assumed situational models addressing the key concerns in the warfighter's view of the world. This world-view situational model will be utilized to identified which valued information to deliver to the warrior in a real time

manner. These information requirements delivered by the VIRT enabled system, provide a capability to not only deliver information deemed valuable to the user but also discard information with little or no value. These valuable informational bits might include fuel levels of assigned aircraft, time on station of each aircraft, relay of video feed from multiple UAVs, etc. Similar informational items referring to other AOR's may exist but present little to no value for a JTAC not assigned that area.

The incoming aircraft may be called off at anytime by the JTAC. However, after the aircraft enters phase III, it becomes much more difficult. If the medevac status were being monitored, and a CM employed, the CM could have monitored the positional COI and automatically notified the JTAC that a problem exists. The JTAC thus calls off the AC-130 attack on the truck. If the CM could monitor the fuel status of the AC-130, then the JTAC would know right away that the aircraft will not be able to stay on station to destroy the target.

Once the CM detects a problem, the JTAC can move forward with an alternate plan. This assumes that the sooner the JTAC knows of a change or problem with a plan, the sooner he can make appropriate changes and elicit a better outcome. This allows the JTAC to have a much quicker decision cycle. For example, if no aircraft exists that can fulfill the mission and the central JTAC must make a call, he can be notified of the condition early and he can then vector another aircraft off their main mission to engage the truck.

All of these COIs must be input into the CM in some user friendly way. This input mechanism must be easy for the user to interact with and must bring together available sensor data into a presentable way the user can make sense of. Most individuals are familiar with Windows and the use of drop down menus. Thus, implementing the familiar look and feel of a Windows-based system seems the easiest way to make this type of VIRT system most accessible. While the actual application does not need to be a Windows product, the comfort level of users will increase if it mirrors some of the basic properties. Thus the actual implementation would be best served by a form of graphical user interface (GUI) with which the user can interact.

This interface will prompt the individual user to enter conditions to monitor. These conditions can be presented in the form of drop down menus based around dynamically changing sensor (human or machine) feeds. Moreover, the individual user can be assigned a role and have pre-selected COIs already loaded for him. In this example, the user is a JTAC. The system will know this user type will want to know standard sensor information. All the user will need to load is his intended location, area of responsibility (AOR), and adjust any of the pre-selected COIs. Such standard information could be the position of friendly units in his area, scheduled flyover of aircraft, known enemy hotspots, civilian use areas, etc. These can be pared down by the user if he so desires. Furthermore, the JTAC may enter additional COIs dependent on the specific mission. Figure 4 shows a suggested GUI mock-up illustrating the initial input screen the user would access.

WARRIOR FEED

ROLE: JTAC (selected), JTAC, Battalion CDR

DEFINE AOR: Map Input

ADDITIONAL COIS:

- Aircraft has no targeting pod
- Targeting POD not at correct angle
- Aircraft payload not as planned
- Weather
- NSFS intersects aircraft flight path
- OFFOR position changes (unplanned)
- Main target changes

ALERT METHOD: RADIO (selected), RADIO, E-MAIL, PDA

ROLE DEFINED COIs:

- ☒ Air contact in AOR intersects planned ordnance delivery path
- ☒ Change in Opfor posit
- ☒ Friendly forces posit change from scheme of maneuver
- ☒ Assigned aircraft change
- ☒ Mission abort by CDR
- ☒ Incoming vehicle movement With intersection in AOR
- ☒ New Non-combatants in AOR

MODIFY

MAP CURRENT UDOP ENTER

Figure 4. User GUI Mock-up

Once a role is selected, the pre-loaded COIs are presented on the right side of the screen. If the user wishes to change any of these COIs, he may select MODIFY and continue to another screen (Figure 5) which will allow viewing or changing all conditions which compose that particular COI.

WARRIOR FEED

SELECT ROLE: JTAC (selected), JTAC, Battalion CDR

	Select Entity	Operator	Scope	Define Area	Alert Method
<input type="checkbox"/>	Blue Forces	unplanned move	in (default)	gridded area	alert via PDA
<input type="checkbox"/>	Select Entity	Operator	outside	Default AOR	alert via Default
<input type="checkbox"/>	Select Entity	Operator	in (default)	Default AOR	alert via Default
<input type="checkbox"/>	Select Entity	Operator	in (default)	Default AOR	alert via Default
<input type="checkbox"/>	Select Entity	Operator	in (default)	Default AOR	alert via Default
<input type="checkbox"/>	Select Entity	Operator	in (default)	Default AOR	alert via Default
<input type="checkbox"/>	Select Entity	Operator	in (default)	Default AOR	alert via Default

MAP CURRENT UDOP [ENTER]

Figure 5. Modify/Add COI screen

Once the user accepts all COIs, the user will continue back to the initial screen and define his operational AOR. Moreover, the user can select how he would like to be alerted. For instance, the alert may go out over some automated voice link or via email (if the user has that capability) or via a Personal Digital Assistant (PDA). Furthermore, the PDA could be set to receive alerts in different forms, e.g., loud beeping or vibration. This depends on the mission and circumstances the user finds himself in. While a PDA device would offer some level of sophistication, the use of a PDA is not a pre-requisite for implementation. Simple alerts may include radio tones the user associates with

certain types of conditions or a text to speech (TTS) alert. The TTS alerts the user by issuing an automated voice message that, once acknowledged, would cease. Some potential alerts are addressed in Table 2.

Alert	General Properties
There is an unplanned friendly medevac moving in your AOR.	COI monitors for unplanned air contact. Once identified, an automated voice message is sent over VHF. "JTAC Lima Bravo, there is an unplanned friendly helo in your AOR. Position of contact is on grid ____ and 120 degrees relative to your current position. Please acknowledge, over." JTAC response: "Rgr, out"
Civilians reported in your AOR. These civilians were not planned for in the mission.	COI monitors UAV and positional data. The civilians are reported via UAV asset. Automated voice report sent. "JTAC Lima Bravo, UAV reports new neutrals in your AOR. Position 120 degrees relative at 2km. Do you want visual feed? Please acknowledge, over." JTAC response: "Copy, Affirmative" If he wishes to receive the video (and has the capability) or "Copy, out" if he does not want the feed.
BFT signals departure from planned scheme of maneuver	<u>If PDA enabled</u> : Alert tone sounds on the PDA (or if in a clandestine situation, vibrates). The JTAC pushes the acknowledge button and views his PDA. The new position of the blue force is displayed and blinks until acknowledged again. This way, the system knows he received the alert and also knows he received the updated position. All the JTAC has to do is push a button twice.

Table 2. Alert Methods and Properties

The 'map input' button will link to a user screen (Figure 6) which will allow the user to "click and drag" to select their assigned area of operation. Coordinates identified here will feed the COIs with positional data relevant to the user.



Figure 6. Map AOR Input Screen 1 (Google Earth)

In this exemplar, the JTAC needs to know a medevac helo has lifted off in his AOR. The JTAC doesn't require any further information pertaining to this helo unless the helo's intended fight path intersects a block of space planned for ordnance or other aircraft to occupy. If the helo inadvertently enters a standoff area, the danger to the helo would require suppression of fires until the helo has passed. In this case, the JTAC would input a COI indicating immediate notification via combat PDA signal (Figure 7) that the helo will be intersecting the intended path of incoming ordnance. At this stage, the JTAC will need to make a decision whether to call off the incoming bombing run or attempt to vector the medevac away from the operational area.



Figure 7. Combat PDA

1. Me-Centric Considerations

Current efforts to link myriad sensor data focus on the net-centric aspects of network connectivity, security, etc. However, this focus should not lose sight of the warfighter. The typical terrorist target in asymmetrical warfare carries very little gear which allows him greater mobility. Technology implementation should focus on reducing weight while increasing combat effectiveness. Currently, a typical table of allowances (TOA) for a Machine Gun (MG) team carries 1000 rounds per gun. At 7 lbs per 100 rounds, this equates to an additional 70 lbs dispersed through the team, and most times the gunner only carries 100 rounds leaving the remaining 63 lbs to be split between two people. Consider also that the MG Team has a 6.6 lb spare barrel, flak, kevlar, two ceramic plates, while the team leader. The ammo bearer has an M16 with 7 magazines, grenades, maybe even Personal Role Radios (PRRs), water, chow, personal night vision, and additional items prescribed by the unit. The riflemen may also carry the personal

gear mentioned above, as well as an extra Squad Automatic Weapon (SAW), ammunition, extra mortar rounds, extra Shoulder Launched Multi-Purpose Assault Weapon (SMAW) rockets, breaching kits, AT-4s, etc. Ounces become pounds, and pounds produce pain. Marines need to move quickly in a combat situation, and the extreme weight reduces their fluidity.²⁶

Thus, pushing information to the edges should not increase the amount of weight or equipment the individual unit must carry. Currently, the JTAC mission as part of the Tactical Air Control Party (TACP) requires a JTAC and three radio operators. Their typical load out of equipment and arms involves lugging around a few hundred pounds of equipment. The Marine Corps developed the Target Location Designation Handoff System (TLDHS) for their FACs as a replacement to the AN/PAQ-3 Modular Universal Laser Equipment (MULE). The unit consists of a day-night laser rangefinder, a laser designator, and a computer component for digital message processing known as a Target Handoff System. As evidenced from Figure 4, the additional equipment load for a JTAC utilizing the TLDHS involves two additional radios, a computer, laser binoculars and power supply. The system must be calibrated prior to initial use which requires the operator to turn in a 360 degree manner to facilitate the system obtaining current bearings.

The burden of using the TLDHS system is addressed in section IV of this paper. However, using a variant of the TLDHS in application of Theory II may be appropriate.

²⁶ Sgt Maj Donnie R. Barrett, "For the record: A Marines Eye View of Better Combat Gear" Military.com, July 21, 2005: Accessed February 2008.
http://www.military.com/NewContent/0,13190,Defensewatch_072105_View,00.html.

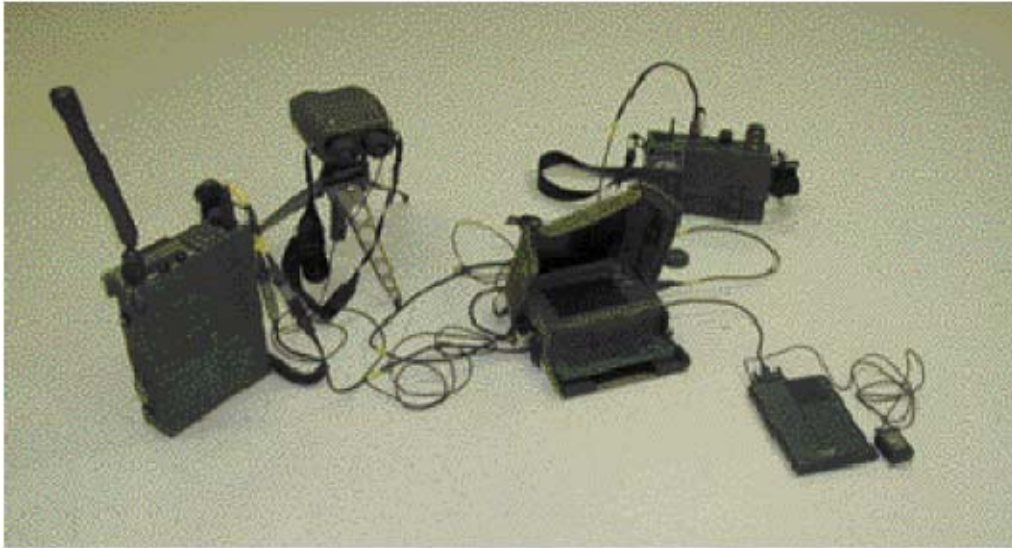


Figure 8. TLDHS Equipment load

The current communications plan the JTAC follows places him on the Tactical Air Detection net (TADNET). If multiple sections of aircraft exist, there will be multiple TADNETs. A radio operator is concurrently on the TACP local or Supporting Arms Liaison Team (SALT) network. This TACP net is a UHF net utilizing the AN-PRC-119F radio and is usually connected to the Air Officer (AO). The Tactical Air Request Net (TARNET) requires monitoring also. The guarding of the TARNET usually falls to an optional person who normally does not accompany the TACP, therefore the guarding of this net falls to someone else who may be focused on another radio net. Moreover, another Marine carries the ground laser target designator (GLTD) and the Vector 21 binocular laser range finder.

Clearly, the impetus should not only be on linking sensor data but on how best to deliver this information to the warfighter without increasing his payload. Indeed, technology should involve solutions to decrease his payload. This 'me-centric' approach could have an ultimate goal of only one smart radio and one combat PDA in the field to free up personnel for other duties as well as increase the movement of personnel. If the JTAC, for example, is limited to an OP due to the limited mobility of his TLDHS system, the military is potentially sacrificing mobility and forsaking an essential capability for adapting to a dynamic battlespace.

IV. OBSERVATIONS AND CONCLUSIONS

A. IS SMART PUSH BETTER?

If the overall goal of the GIG is to create a simple union of disparate sensor and intelligence data accessible through a vastly distributed database, DoD's current approach might prove sufficient. If the end-state seeks to link this same sensor data in order to deliver valued information where and when necessary without placing a burden on the warfighter to actively access it, the GIG probably will fall short. The as-is approach may often produce mission success, but it sacrifices many opportunities for increasing combat effectiveness and faster massing of force. If IT can be utilized to assume much of the mental processing and physical tracking that now must consume people's attention, potentially more targets can be engaged and threats identified more quickly. This will lead to more choices for the warfighter by providing better knowledge. Moreover, if the overall goal seeks to offer a useful tool within a reasonable time frame of a few years, the current approach fails. Smart Push relies on utilizing existing technology in a smart way to allow warfighters to express conditions of interest and be alerted should their fundamental assumptions change or the worldview they hold becomes invalid in a way which will influence their mission.

Clearly the warrior on the frontline will utilize whatever tools he possesses to complete the mission. Currently, he uses bits and pieces of high technology but the true nature of a NC force has yet to materialize. The GIG wishes to achieve a vision of readily accessible information through ubiquitous database accessibility. Pulling this information will be the responsibility of the warfighter. Someday, when a warrior fails to make a link between available information and the situation on the ground, someone above him in the chain of command might say, "Well Captain, the information was out there, you just didn't pull it down quickly enough." This presents an unacceptable reality that could very well occur in the future. Instead, efforts should focus on the best way to funnel valuable information to the warrior when and where needed. Smart Push promises this type of information delivery where smart pull does not. This does not presuppose the

warrior will make the proper decision 100% of the time, but it does work to ensure he has all relevant information possible prior to making the decision. Thus, if a warrior fails in the future under a VIRT scenario, the Commander will say, “Well, Captain, you made the best decision you could with the information then available.”

B. CONCLUSIONS ABOUT JTAC

The use of the JTAC mission exemplifies how technology may be utilized in a smart way to push valued information where needed. This scenario represents an extremely important mission but many more missions of similar importance need consideration. These missions include a myriad of activities from calling in fire support or a battalion level maneuver effort. These very important missions should be addressed first. The idea of the GIG tends toward an approach where the information becomes available for easy access. The onus needs to be taken off the warfighter and placed on technology to monitor ISR resources and push valued information.

The JTAC mission serves as an excellent example because it shows very well the grass roots effort it took to get the joint CAS mission adopted and recognized across the services. This effort mirrors the way ahead in smart technology delivery. Instead of concentrating on a top-down “global” vision for technology that may never be accomplished, the focus should turn to current missions of high value where proper smart information delivery, e.g., VIRT, can deliver more capability today. The sheer amounts of information that will become available and seemingly indispensable will undoubtedly increase. For example, the success of the JTAC concept will lead to the creation of even more JTACs. This effort may take the form of placing a JTAC with every company in the field. Pursuing this approach without instituting some form of smart information management in the form of a VIRT filter may lead the services to inadvertently increase the risk of a clouded battlespace. Couple this risk with increased complexity of communication and it all points to an increase in the fog of war.

C. FROM JTAC TO OTHER JF MISSIONS

The fusing of disparate sensor data across the services has continued to be a challenge for JFCOM. Overcoming parochial interests in the name of better information delivery for all continues to confound even the most ardent supporters of “joint think.” However, these issues must be overcome. Current efforts at joint integration focus on systems, e.g., Link 16. The goal becomes fusing sensor data among platforms. This effort has not necessarily led to more capability to the warrior on the ground. The focus has centered on providing a COP. This COP provides useful sensor data and positional reports to commanders but stops short of providing the real-time information necessary on the ground. The desired end result is a more agile battlefield commander able to look at any aspect of the battlefield. However, the goal should not be to make commanders omnipresent and omniscient. Instead of focusing technology to enable a commander to drill down to the operational arena and second guess the guys on the ground, technology should focus on utilizing the available sensor data to enable a more effective warrior on the ground by providing everything relevant to achieving mission success.

The most effective approach would involve determining what holds great importance to each service by considering in detail mission-specific examples. These missions would become the focus of JFCOM. The JTAC serves as only one of many examples the JFCOM could refine and prioritize. Fusing sensors must focus on the information needs of the warrior. The questions which should be posed revolve around how best to deliver additional capabilities today. The lesson appears to involve pushing available valued information to the warrior who may then act faster than the enemy. A commander, even with a 100% accurate COP, cannot hope to make decisions fast enough at this macro level to effect real change on the battlefield that will lead to victory. The warrior still has the best hope of effecting real change in the battlefield outcome. This warrior must be given every available tool to succeed.

D. DYNAMIC WORLD MODEL

1. Self-Synchronization

The DoD shift to joint thinking underlies a fundamental belief that new or enhanced capabilities may exist if only the individual forces can pool their resources to self-synchronize. Indeed, within each individual service the pervasive belief is that an enhanced force can result from the synchronization of all relevant information sources. Self synchronization “...is a mode of interaction between two or more entities.”²⁷ This effort involves two or more networked entities, shared awareness, a rule set and a value added interaction (Figure 9). Mostly, the DoD effort has centered on a systems type of thinking. This may seem natural because these existent systems take up a great deal of resources. An example may be the overall logistics system or fire support systems.

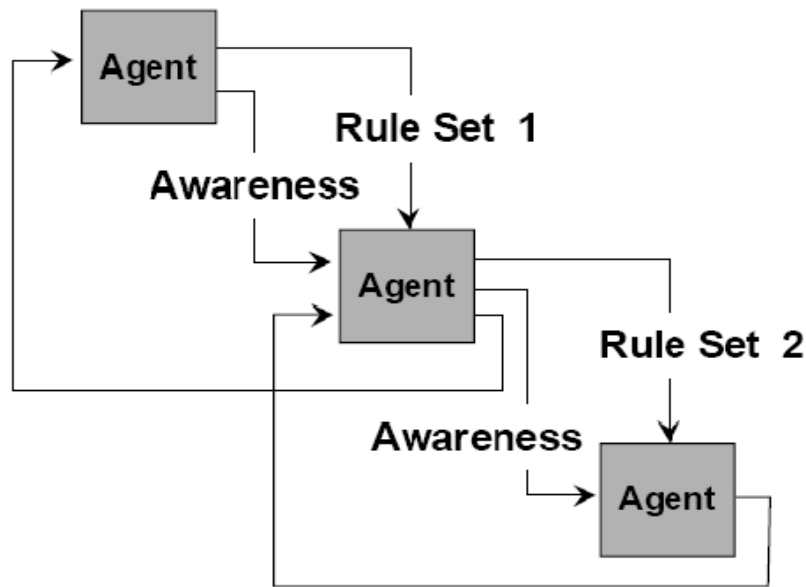


Figure 9. Self-Synchronization Interaction (Gartska)

The model in Figure 9 does not address hierarchical levels of concern. For instance, the amount of control an entity possesses corresponds directly to the level in the hierarchy they personally hold. For instance, a theatre commander has a different level of

²⁷ John Gartska and David Alberts, Network Centric Operations Conceptual Framework Version 2.0; June 2004, 175.

control then the warrior on the ground. The model in Figure 9 as outlined in the Gartska NCW work, does not adequately address these levels. A model developed by Professor Hayes-Roth, *et al.*, goes further by stratifying the levels of concern and including such elements as time. Figure 10 illustrates the Distributed Intelligent Control and Management (DICAM) architecture. This presents a much clearer understanding of the elements involved in command and control. The y axis serves to stratify “stored information at high to low levels of aggregation in order to serve the needs of controllers with corresponding levels of responsibility.”²⁸ The Z axis corresponds to the different types of information and the X axis corresponds to time. This architectural model goes much further in considering all elements necessary for critical information consideration including the relative level in the hierarchy of the decision maker, i.e., the controller.

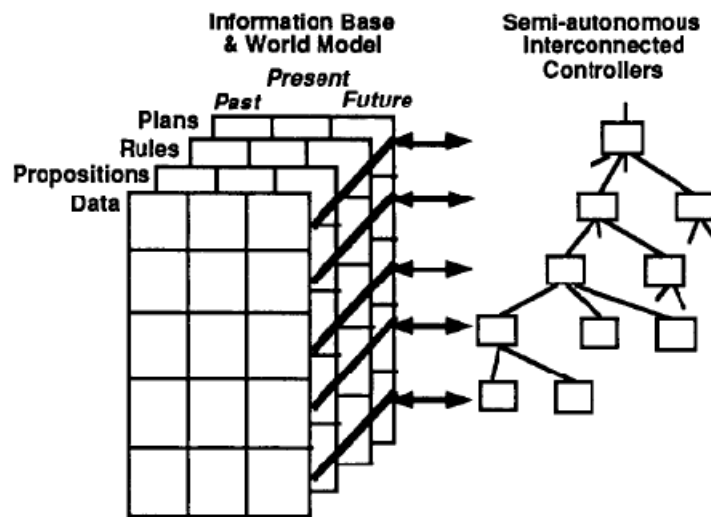


Figure 10. The DICAM Reference Model (From: Hayes-Roth, *et al.*)

The next step in this process requires the realization of a dynamic world model of each individual mission requiring VIRT implementation. The JTAC mission should be a good starting point. By implementing smart monitoring, the JTAC could receive great benefit by applying it to other potential information entities. The scenario addressed in

²⁸ Frederick Hayes-Roth, Lee D. Erman, Allan Terry, and Barbara Hayes-Roth. Distributed Intelligent Control and Management: Concepts, Methods and Tools for Developing DICAM Applications contained in IEEE publication. 237. Available at <http://ieeexplore.ieee.org/iel5/413/5910/00227923.pdf?arnumber=227923>. Accessed March 2008.

this thesis does not include all of these items. This thesis pares down the number of items in order to simplify experimentation and still show the value VIRT has to offer. A number of items which could be monitored include:

- the assigned altitude blocks for each aircraft.
- the target that each aircraft is planning to attack (i.e., where his cursor is pointing).
- the actual location of each aircraft and ordnance on board each aircraft.
- the location of each indirect fire unit and the target location of any indirect fire unit's current mission (with a trajectory line and warnings if it violates any assigned airspace).
- the location and route of helicopters such as casualty evacuation (CASEVAC).
- the current ATO status in timeline format.
- unit boundaries and fire support coordination measures (updated as they change).
- known and suspected enemy locations, friendly locations, and known civilian or neutral force locations.

A majority of this information may be found in one system or another, but there is no unified system that puts it all together in one place, monitors for important changes, and makes it actionable for a mobile JTAC.

E. WAY FORWARD

1. Institute Experimentation and Proceed to Exercises

The natural progression for this thesis requires actual experimentation and demonstration of the scenario. Empire Challenge 2008 can be the venue for this demonstration. This demonstration will be limited to available sensor information but will illustrate well the efficacy of VIRT implementation and the value that may be

garnered now. This experiment can be set up to resemble closely the current command structure for a JTAC in the field. A run-through of the scenario based on current technology or how the mission would be done without VIRT would constitute a baseline for comparison. The measurement of available cognitive ability would be hard to measure but a simple survey of the person placed in both a current environment and VIRT environment could be useful in determining how much effort it takes to engage in both environments. Moreover, traffic on the circuit could be measured to see if the actual number of bits is reduced or, more to the point, whether the percentage of valuable bits increases.

2. Capture Integral Missions Now

The theory of natural selection applies very well to the adoption of technology. Those who apply technology well will survive and those who fail will die. Moore's Law indicates computer power/memory doubles every 18 months. The conservative four year lifetime estimate for a computer means total Internet computing power doubles every 10 months.²⁹ This natural process of technology growth does not mesh well with the decades old DoD acquisition process. By the time a new technology application can work its way through the bureaucracy, it has become obsolete, the additional capabilities once promised now diminished or negated. Thus, the return on investment is worse than zero: it becomes a negative sum gained even before considering the cost of lost opportunities.

The idea of natural selection, however, may be utilized in favor of DoD technology discovery and implementation. As stated before, the focus of technology implementation should be on capturing integral missions now. Instead of pouring billions of dollars into grand or "global" schemes of integration, mission-specific applications should be captured now. The first missions to consider should be those that offer the greatest return on investment, e.g., the JTAC mission set. Moreover, several potential agencies performing similar functions can propose their own unique solutions. Funding may be made to each one and the best idea will be the one adopted and

²⁹ CCIA Security problems, 7.

implemented. Furthermore, the overlapping of missions could be studied to discover the approach each service implements to solve a common problem. Develop a comparison methodology and select the one that solves the problem best. Make that particular service the lead agency and adopt the solution across all the services with a focus on interoperability. In other words, select the best of the best and kill the rest.

3. Build upon Current Tools

The current stovepipe style of systems acquisition has had a negative impact on the interaction between the services. The acquisition of the TLDHS serves as a great example technology adoption with little to no interoperability. This system has a great deal of promise and could be scaled to encompass the other service's needs. The cumbersome and unreliable nature of the Marine Corps' MULE program led to its retirement. Its replacement, the TLDHS, has proved equally cumbersome as well as not interoperable. As a result, JTACs in the field do not use it. Voice communications is deemed more reliable and so is utilized almost exclusively. However, the TLDHS does show promise and may be an example of how best to utilize developed technology to interconnect the services and build a common framework.

4. Smart Push is the Way Forward

JFCOM must balance a limited budget with the great demands of COCOMs and military personnel to include technology throughout most aspects of warfighting. JFCOM must advocate and insist upon the utilization of flattening technologies that interoperate among all the services. This may include a modification of the JFCOM mission as the central clearing agency for technology integration among the services. There has to be a clearing house for technology insertion into U.S. forces. If the JFCOM does not become the central agency for technology alignment, they will be forced to become the central agency for technology fusion. This fusion will increasingly become a hopeless task. As each of the services continue to procure service-specific technology with no common integrative architecture, the fusion of these technologies between the services will become an insurmountable task. Moreover, the time it takes to implement

anything must be considered. No longer can this nation stand idly by and hope its expensive efforts will yield good results. Our adversaries have woken up and adopt technology to their use at an ever increasing rate.

Clearly terrorists are adopting technology without large acquisition projects. They form their own networks based around current technologies including cell phones, the Internet and cheap explosive devices. The power of this type of fusion has been painfully obvious in both Iraq and Afghanistan where remote bomb detonation and relaying of U.S. force positions utilize existing technology. However, the difference in scale of investment between the U.S. and terrorists is staggering. While the U.S. invests billions of dollars in large acquisition projects, the terrorists are utilizing available technology and adapting it to meet their goals. Perhaps the U.S. should shift its focus from the large projects towards more effective practical solutions focused on mission-specific areas.

Current approaches to technology software and hardware implementation follow a roughly ten-year cycle of acquisition and integration. This is too slow by an order of magnitude! The world is changing too fast and this cycle will not lead to a modern force infused with new capabilities capitalizing on technology implementation. In *The World is Flat*, author Thomas Friedman utilizes an analogy of the lions and the gazelles. Each night the gazelle sleeps knowing that tomorrow it must run faster than the lion if it wishes to live. Each night the lion also sleeps knowing tomorrow he must run faster than the gazelle if he wishes to live. So, regardless of whether you are the lion or gazelle, when morning arrives, everyone wakes up and runs. It appears as if the U.S. military has woken up but believes it can walk and win. The adoption of technology must quicken and be implemented smartly if the U.S. wishes to run. The good news – the U.S. has woken up. The bad news – the U.S. has not started running.

F. FUTURE WORK

- Extend the concept of VIRT to include other humans in the loop e.g., the coordinating JTAC in charge of several field-level JTACs.

- As discussed in section III of this paper, the human animal has a limited cognitive capacity to process information. Professors Miller and Chattuck of the Naval Postgraduate School have developed a Dynamic Model of Situated Cognition (DMSC) which can be well applied to the JTAC, including more robust M2M and human interface technology. While many models of NCW focus on the technological aspects of a system, the DMSC was developed in order to represent relationships between technology and humans in the system.³⁰ A future study should employ this model in the context of the scenario contained in this work.

G. FINAL ANALYSIS

This paper has presented a true-to-life use-case scenario for comparing current information delivery to a smart push alternative. As the sheer amount of information increases, current practices will not yield better results. The JTAC currently utilizes three radio personnel to keep up with information updates. This process does not present the best utilization of technological resources and available computing power. By allowing the JTAC to specify certain COI's and enabling computers to manage the updates, the amount of information the JTAC must consider will be reduced to a manageable level. This allows the JTAC or any other entity utilizing smart push to focus more on the mission thus becoming more agile in the process. "For our organizations to get the best results, the human resources need to spend their limited time on the most important things."³¹ The smart pull envisioned by the DoD in the form of the GIG may provide a static repository of information but does not provide the warfighter with a tool to dynamically deliver information to the warfighter when and where needed the most – the battlefield. Instead of the DoD beginning at the top with an enterprise-wide solution, they should focus on the most valuable missions first. The JTAC presents just that type of mission and this should be where the effort begins.

³⁰ Nita Lewis Miller and Lawrence G. Shattuck, "A Dynamic Process Model for the Design and Assessment of Network Centric Systems," for 2006 Command and Control Research and Technology Symposium The State of the Art and the State of the Practice; 2.

³¹ Rick Hayes-Roth, "Model Based Communication Networks and VIRT: Filtering Information by Value to Improve Collaborative Decision-Making," for 2005 10th International Command and Control Research and Technology Symposium; 20.

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